scale. Thus a note of any desired pitch can easily be obtained, but the intensity varies on account of the varying sensibility of the ear and the apparatus. This possibility of variation of pitch makes a number of new methods of wireless signalling feasible. One of the easiest resembles a very early kind of moving needle telegraph apparatus called Bright's bells in which the needle moved to one side and struck a bell in order to indicate a dot and moved to the other side and struck a bell of different tone to indicate a dash. This method was faster than the dot and dash sounder and apparently easier to learn. In its proposed wireless form the transmitting station would emit equal wave trains to represent dots and dashes, say of 200,200 frequency to represent the dots and 200,500 frequency to represent the dashes. Each Morse sign is then heard as a little melody at a receiving station using a local oscillator of 200,000 frequency. Besides the advantage mentioned above there is a likelihood that these signals would be less distorted by atmospheric discharges than are longs and shorts of constant pitch.

Still another simple method consists in utilising three very close high-frequency oscillations at the transmitting station, say 200,200, 200,100 and 200,050, and making a new code for the alphabet out of permutations of these. The local oscillator would have a frequency of 200,000, and therefore the sounds heard in the telephone would be short tunes. The method would be faster than Morse, but might demand that the operators should have musical ears. Still another method can be imagined in which chords of three notes instead of arpeggios are used for the letters of the alphabet, but this might require an even more musical ear.

But there is one kind of chord which every one can recognise without special training, which even the horse can discriminate in the sounds of "whoa" and "gee." The vowel sounds are in fact chords. Lately Sir Richard Paget has given (Vowel Resonances, International Phonetic Association) a list of the chief tones occurring in the English vowels. For example, the vowel sound in the word "calm" contains the tones of frequency 1360 and 810 per second. Suppose, therefore, a transmitting station is arranged to emit simultaneously electric waves of frequencies 201,360 and 200,810, and suppose these waves when received at a great distance are combined with local oscillations of frequency 200,000 per second. Then the tones 1360 and 810 are perceived simultaneously as a chord in the operators' telephones. But this chord by itself is scarcely if at all recognisable as a vowel. Recognition is ensured by superposing a larynx note by aid of a buzzing contact included in the receiving circuit. Then whenever a train of two waves leaves the sending station the vowel is pronounced by the receiving apparatus. This is easily illustrated to an audience by the aid of a loud-speaking telephone. Lecture apparatus for producing and detecting the two vowel sounds represented by *o*, *a*, is shown in Fig. 9. The change of

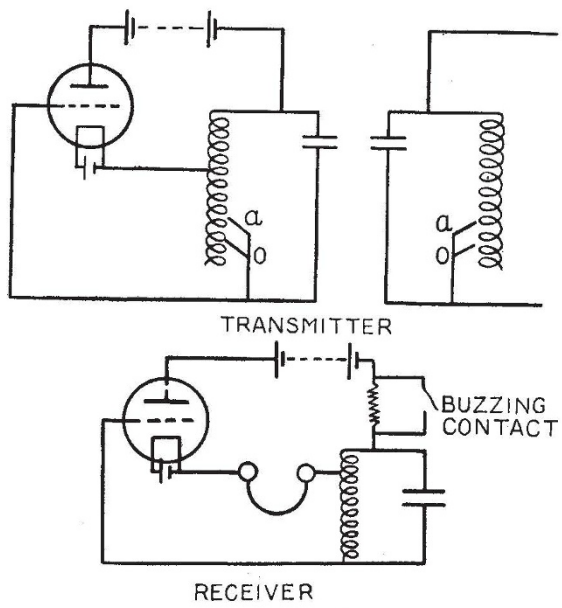

FIG. 9.—Heterodyne vowel apparatus.

radio frequency necessary for passing from one vowel to another is provided by the tappings on the inductance coils. In this apparatus the transmission occurs across a short distance; in practical telegraphy the transmitter would be more powerful and would be provided with an aerial and the receiving apparatus would also have an aerial.

The apparatus, which was built and made to work by Messrs. C. F. A. Wagstaffe and E. S. Smith, two former Finsbury Technical College students, was constructed to produce six vowels, namely, those heard in the words eat, all, hate, shoe, calm, and earth. These six vowels taken in pairs yield thirty-six symbols which, together with the five vowels *a*, *e*, *i*, *o*, *u* representing themselves, amount altogether to forty-one symbols. An alphabet formed in this manner is much briefer than the Morse code; that is to say, there are fewer efforts of the sending key in making the same message. For example, in the word London there are seventeen efforts when Morse is used but only eight when the vowel code is employed. Besides the gain in speed there is a possibility of reception through atmospheric disturbances being more easily accomplished with the vowel code than with the customary dots and dashes of constant pitch, but this can only be tested by actual trials.

Ur of the Chaldees.

By C. LEONARD WOOLLEY.

IN 1919 Dr. H. R. Hall, on behalf of the British Museum, spent three months excavating at Ur. Last summer the British Museum and the University Museum of Philadelphia decided to send out a joint expedition which should continue for a term of years the work begun by Dr. Hall, and clear as much of the site as seemed likely to repay the necessarily heavy cost of a scientific mission. The first season's work of the joint expedition is now over, and the results amply justify the confidence of those who promoted it, and give every promise of even greater success in the future.

Mesopotamian sites are often on a very large scale, and though Ur cannot compare in this respect with Babylon, yet the mounds of the ancient city, spreading in length for some three and a half miles, afford a rather bewildering scope to the excavator. At Babylon, in the course of their eleven years of work, the Germans excavated a number of the most prominent mounds, with excellent results; but there is this drawback to the system, that we have in consequence a number of important buildings or groups of buildings isolated from one another, and can deduce from them very little regarding the lay-out of the town plan. At Ur it will take many seasons to obtain anything like a plan of the whole city, but luckily we are, even thus early in the day, able to learn a great deal about the most important element in the city —the "temenos" or sacred area wherein lay the principal temples and the palace of the king.

Dr. Hall had dug one section of the wall which enclosed this temenos. Last season we traced it for nearly its whole circuit and cleared four out of the six gates by which it was pierced. Inside it the great ziggurat or storied tower of brick is unmistakable, forming, even in its ruined state, a landmark visible for many miles. Dr. Hall excavated part of a building which we have identified as the sanctuary of the great temple of the Moon-god Nannar (the greater part of it has still to be dug). We have completely cleared a smaller temple dedicated to the Moon-god and his consort; and we have been able to fix with tolerable certainty the position of two other temples and of the royal palace. Already, therefore, we know not a little about the topography of the temenos; and as by means of air-photographs we have been enabled to trace, without digging, much of the main outer wall of the city, the problem of where work can most fruitfully be done is simplified to an unusual extent.

The temenos wall was built, as numerous clay dedication-cones inform us, by Ur-Engur, the king who founded the Third Dynasty of Ur about 2300 B.C. It is a hollow or compartment-wall, each wall being over 9 feet thick with 13-foot chambers in the interior. Built of unbaked mud brick, its face relieved by vertical double-rebated grooves, it still stands in places nearly 10 feet high (Figs. 1 and 2). But the existing brickwork is by no means all of the founder's date. Often in its long history it was patched or rebuilt, and in the gateways (where of course repairs were most frequently required) we find records of later restorers dating from Ur-Engur's own grandson, Bur-Sin, to Nebuchadrezzar, king of Babylon (600 B.C.), and Cyrus of Persia (*c.* 535 B.C.). Soon after Cyrus's time, perhaps in the middle of the 5th century, the temenos wall, with all the temples which it enclosed, was destroyed by Zoroastrian iconoclasts. In one of the gateways, last restored by Nabonidus, Cyrus's predecessor, the scorched brickwork and the charred beams of the gate-chamber roof survived as a testimony to religious intolerance. It was just inside this gateway that we found a headless diorite statue of Entemena, king of Lagash and of Ur about 2900 B.C.; it is probable that this ancient and already mutilated figure was unearthed by Nabonidus, who had a passion for archæology, and set up on the ziggurat in front of the gate.

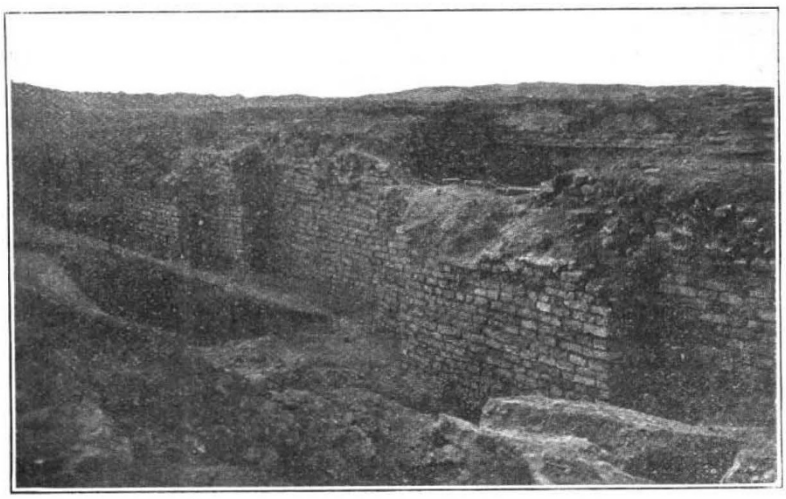

FIG. 1.—Part of the buttressed outer wall of E-nun-makh, the temple of the Moon-god and his consort. The lower part was built by Bur-Sin (2250 B.C.), the upper part by Kudur-Mabug (2000 B.C.): the interior brickwork seen above is by Nabonidus, last king of Babylon (*c.* 550 B.C.). By courtesy of the trustees of the British Museum and the Board of the University Museum, Philadelphia.

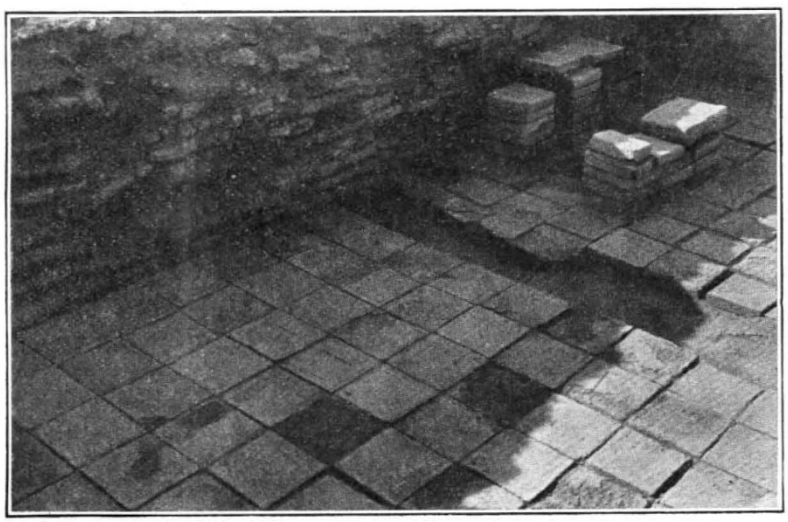

FIG. 2.—Room in the sanctuary of E-nun-makh, the temple of the Moon-god and his consort, showing the old walls, the new floor of bricks laid by Nebuchadrezzar, the side altar with its offering-table, and the groove in the floor for the "chancel screen." By courtesy of the trustees of the British Museum and the Board of the University Museum, Philadelphia.

The temple of the Moon-god and his consort was a foundation far older than the temenos wall. When Ur-Engur repaired it, as he did, it had already been twice rebuilt, and the original builder is lost to us in the mists of antiquity. That the temple was in use by 2650 B.C. we know, for we found in it fragments of decorative stone vases dedicated by kings of Agade at that time—but probably it was venerable enough then (Fig. 3). Bur-Sin, the second in descent from Ur-Engur, three thousand years. Nebuchadrezzar was the first to embark on a radical alteration. The original five-roomed sanctuary had been private, the god's own house, hidden away behind priests' chambers and stores and approached only by a winding passage. Nebuchadrezzar did away with all the service-rooms in front of the door, substituting for them a wide-open court with a smaller upper court whereon stood the altar. The alteration clearly points to a change from a

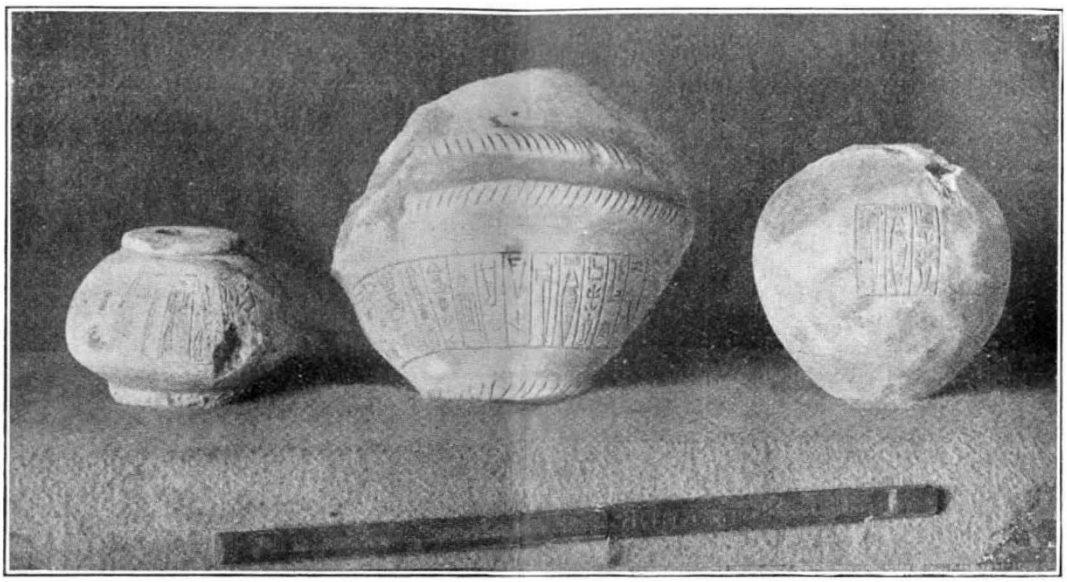

FIG. 3.—1, Votive alabaster mace-head of Ur-Engur (2300 B.C.). 2, 3, Votive alabaster mace-head and vase of Rim-mush, King of Agade (2650 B.C.). By courtesy of the trustees of the British Museum and the Board of the University Museum, Philadelphia.

thoroughly rebuilt the place; so did Kudur-Mabug (about 2000 B.C.) and Kuri-Galzu (four hundred years later); but then, and until another thousand years had passed, the form of the temple remained the same: like a human body regularly renewing its tissues, the old building was still itself though its bricks changed. So careful were the royal builders to keep to the old times that, as a rule, each left one or two courses of his predecessor's building *in situ* to serve as a guide to the new bricklayers, and as a result the lower parts of the walls which survive to-day sandwich into a few feet successive periods of history covering two and perhaps secret ritual to public or congregational worship such as that referred to in the Bible story of the Three Children.

The number of objects found in the course of the excavations was very great, including jewellery of the Neo-Babylonian and Persian periods, ivories and bronzes, hundreds of inscribed tablets, mostly of the time of the Third Dynasty (2300–2000 B.C.), terra-cotta reliefs, carved and inscribed stone vases, pottery, glass and stone beads, etc., etc. A special exhibition of these will be arranged at the British Museum as soon as possible, and illustrated lectures describing the progress of the excavations will also be given.

Current Topics and Events.

THE present outbreak of small-pox in Gloucester is very different from the tragedy of 1895–96. The number of cases in that frightful epidemic was 1981: and the number of deaths was 434. On the present occasion, the number of cases, up to now, has been about one-tenth of that number. As in other places, so in Gloucester, a very mild type of small-pox has appeared: indeed, so mild that, to some people, the very nature of small-pox seems to have changed. Still, the possibility remains that the disease will, some day or other, recover its old virulence. Besides, it appears that some of the Gloucester cases have been serious. Thus, at a meeting of the city council on June 27, the Mayor spoke of "some of the fearful sights" in the wards of the Isolation Hospital, and said that he should never forget them: and the chairman of the Health Committee spoke of "severe and ghastly" cases in the same hospital. Unhappily, so mild were the first cases that they were mistaken for chicken-pox. The best authority on the rules for avoiding this mistake between small-pox and chicken-pox is Dr. Wanklyn: and his writings are worth reading. The mildness of the epidemic, the controversy over its nature, the frequent concealment of cases, and the work of the anti-vaccinationists, have brought about a most unfortunate state of affairs in Gloucester. The fear is that Gloucester is steadily exporting small-pox to neighbouring towns.